



# Development of THALES2 Code and Application to Analysis of the Accident at Fukushima Daiichi Nuclear Power Plant

The NRC's 25th Regulatory Information Conference (RIC)

March 12-14, 2013  
The Bethesda North Hotel and Conference Center  
MD, USA

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## Outline of Presentation

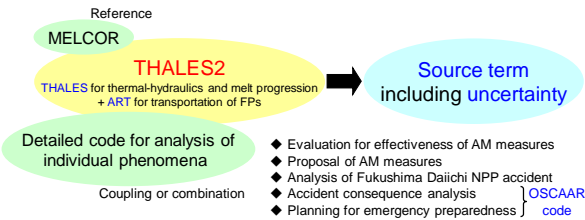
- Overview of THALES2 Code
- Past Studies with THALES2 Code
- Application to 1F NPP Accident Analysis
- Ongoing and Planned Studies
- Summary

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## Role of THALES2 Code

- Integrated severe accident code to analyze source term for level 2 PSA
- Consideration of major phenomena associated with thermal-hydraulics, in-vessel and ex-vessel melt progression and transportation of FPs

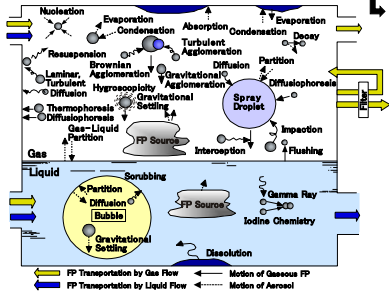


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## Brief Description of THALES2 code

- Fast running capability
  - ◆ Simplified modeling for thermal-hydraulics and core melt progression
- Covering major phenomena for transportation of FPs within RCS and CV with the exception of chemical reactions



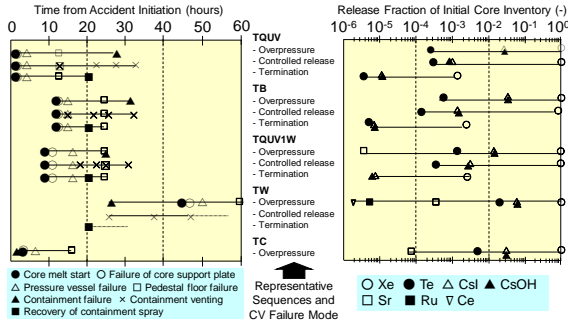
## Past Studies with THALES2 Code

- Source term analysis for various accident sequences
  - ◆ Inputs for accident consequence analysis
- Uncertainty analysis for source term
- Preliminary coupled analysis with KICHE code for containment iodine chemistry



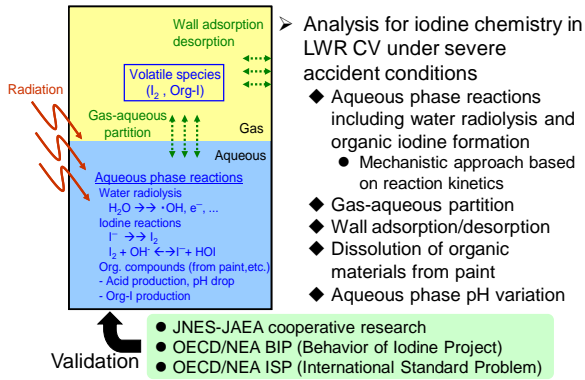
## Output from Source Term Analysis

### Sequence of Events and Environmental FP Release



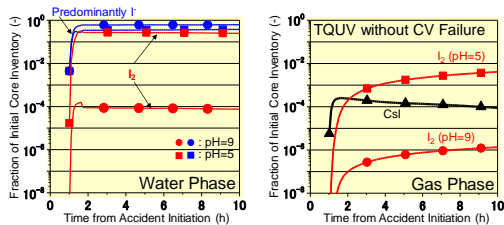
- Identification of major accident sequences (51 sequences) from PSA studies
- Reduction into 5 groups based on the similarity of accident progression

## Overview of KICHE Code



## Coupled Analysis with KICHE Code

### Partitioning of Iodine Species in S/C

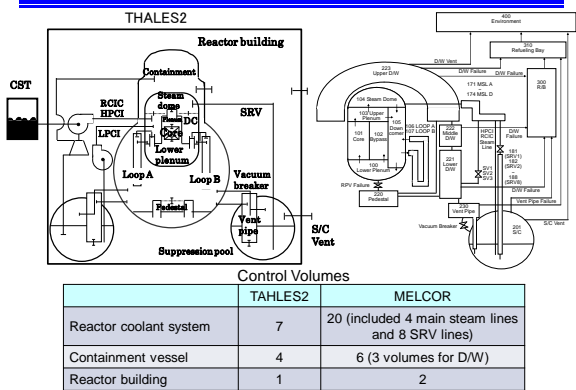


- Significant dissolution of iodine species in water phase of S/C
- Formation of larger amount of  $I_2$  in water phase with lower pH, resulting in volatilization into gas phase
- Importance of pH variation depending on accident progression and applied accident management measures

## Application to 1F NPP Accident Analysis

- Analysis for units 2 and 3 with THALES2 code in parallel with reference analysis using MELCOR code (Ver. 1.8.5)
- Input preparation based mainly on publicly available information
  - ◆ Automatic activation of equipments
  - ◆ Operator actions
  - ◆ Accident management measures
- Assumptions for uncertain parameters
  - ◆ Water injection rates
  - ◆ Failure location and timing of containment vessel (unit 2)
  - ◆ Flood of tsunami water in torus room (unit 2)

Nodalization for Analysis



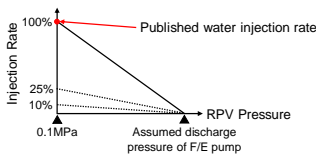
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Conditions of Analysis

	HPCI flow rate*1	F/E flow rate*2	CV failure location
Unit 2	-	10%	D/W gas phase
Unit 3	3.5%	25%	S/C venting

\*1 Fraction of nominal flow rate taking into account operator action to return a part of HPCI water to CST through test line  
\*2 Fraction of published information for water injection rate by fire engine pump

Assumed Pressure Dependence of F/E Water Injection Rate



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Sequence of Major Events

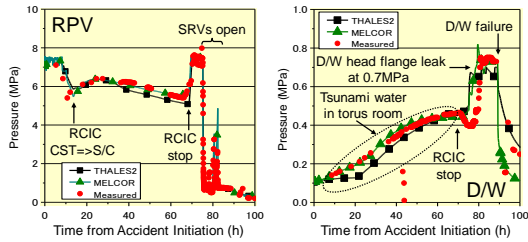
Events	Unit in hour			
	Unit 2		Unit 3	
	THALES2	MELCOR	THALES2	MELCOR
Gap release*1	76.5	76.3	44.3	43.2
Core melt*2	77.7	77.5	44.0	44.3
Failure of lower core support plate	81.0	78.5	46.7	45.3
Failure of lower head	87.6	↓	52.2	↓

\*1 Cladding temperature at 1173K  
\*2 Cladding temperature at 2098K (melting point of Zr)

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## Results of Unit 2 Analysis (1/2)

### RPV and CV Pressures

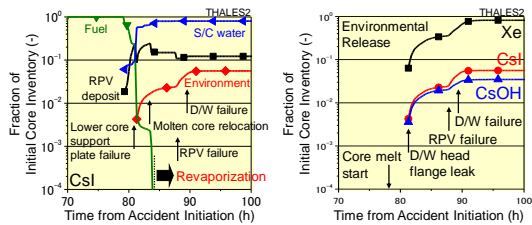


- Similar results between THALES2 and MELCOR codes
- Good agreement with measured data, but not for D/W pressure after stop of RCIC

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## Results of Unit 2 Analysis (2/2)

### Distribution and Environmental Release of FPs

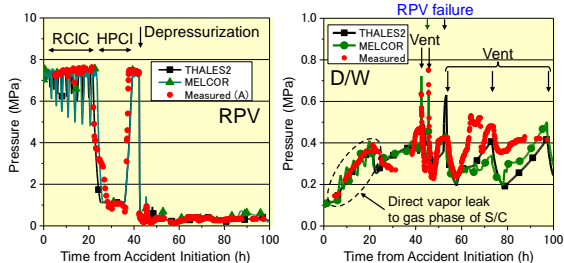


- Significant contribution of revaporization of once deposited FPs onto RPV structures
- Potential for revolatilization of iodine species from water phase of S/C

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## Results of Unit 3 Analysis (1/2)

### RPV and CV Pressures

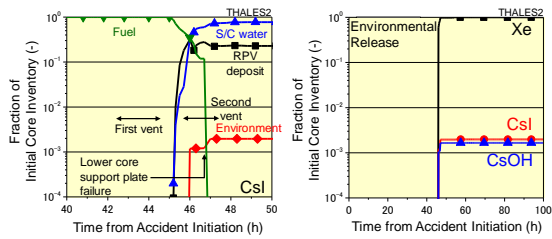


- Similar tendency between THALES2 and MELCOR codes except for timing of pressure peak generation in D/W due to RPV failure

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## Results of Unit 3 Analysis (2/2)

### Distribution and Environmental Release of FPs

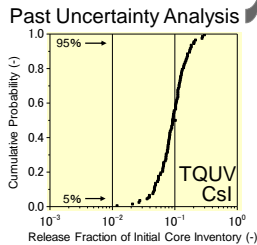


- Most release of FPs during the second venting period through S/C

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## Ongoing and Planned Studies

- Analysis for OECD/NEA BSAF (Benchmark Study of the Accident at the Fukushima Daiichi Nuclear Power Station) project
- Update of uncertainty analysis for source term with the latest version of THALES2 code and identification of important factors to be improved
- Coupled analysis with full capability of KICHE code including time-dependent pH variation and formation of organic iodine
- Continuous modeling improvement for source term and AM measures and application to evaluation of AM effectiveness



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## Summary

- THALES2 code has been developed at JAEA with main target of source term analysis for level 2 PSA.
- Applications of THALES2 code were made to various source term studies, including analysis of the accident at Fukushima Daiichi NPP.
- Improvement and application of THALES2 code are continued in ongoing and future studies.

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